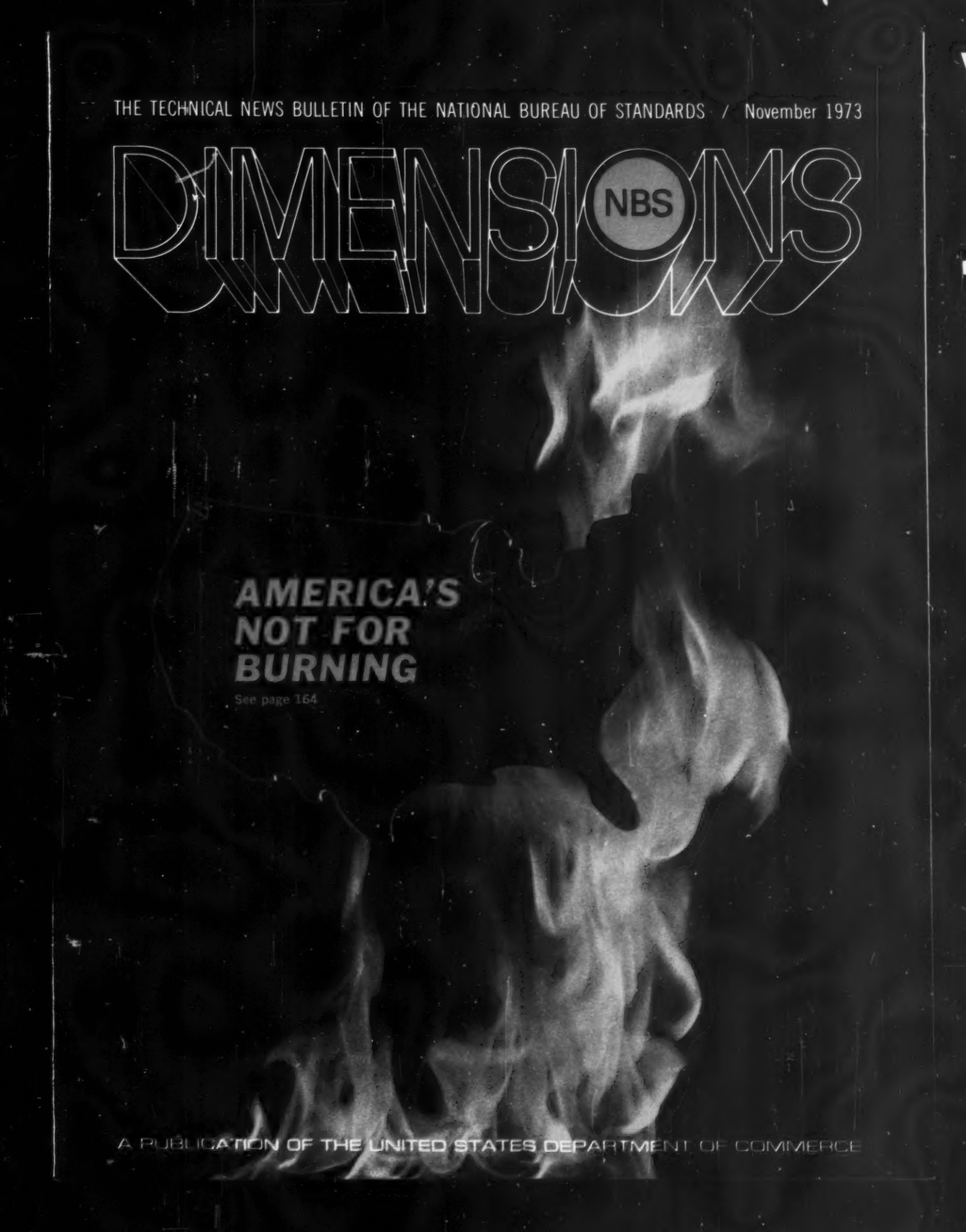
THE TECHNICAL NEWS BULLETIN OF THE NATIONAL BUREAU OF STANDARDS / November 1973

DIMENSIONS/NBS



AMERICA'S NOT FOR BURNING

See page 164

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To curb the losses of life and property caused by fire, extensive efforts are being made to use technology to produce a fire-protected environment. A review of the Bureau's involvement in this area is presented on page 264. Related articles appear on pages 268 and 270.

U.S. DEPARTMENT OF COMMERCE
Frederick B. Dent, Secretary

Betsy Ancker-Johnson
Assistant Secretary
for Science and Technology

NATIONAL BUREAU OF STANDARDS
Richard W. Roberts, Director

Prepared by the NBS Office of Information Activities
Washington, D.C. 20234
William E. Small, Chief

Richard S. Franzen,
Chief, Editorial Section

Sharon A. Washburn,
Managing Editor

Contributing Editors
L. K. Armstrong, J. D. Crumlish, J. Kelley, S. Lichtenstein, R. C. MacCollough, R. D. Orr, A. L. Rasmussen, A. Schach, C. N. Smith

C. Messina, Visual Editor

The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

The Institute for Basic Standards
The Institute for Materials Research
The Institute for Applied Technology
The Institute for Computer Sciences and Technology
Center for Radiation Research
Center for Building Technology
Center for Consumer Product Safety

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HOW HIGH THE MOON?

Lunar Distance Measured More Accurately

A team of U.S. scientists has succeeded in measuring variations in the 235,000-mile distance to the moon with an accuracy of about 6 inches. In the next year or so, they hope to narrow this to about 1 inch.

"Our purpose is to provide better data on the relative motions of the earth and moon," says Dr. James Faller, of the Bureau's Boulder laboratories. "This information then can be used to study continental drift, to measure the wanderings of the earth's poles, to learn more about the complex phenomena inside the earth, and to determine the mass distribution of the moon."

Faller is chairman of the Lunar Ranging Experiment (LURE) team that includes Dr. Peter Bender, also of the Bureau, colleagues from Princeton, Texas, California, and Maryland universities, and workers at the National Aeronautics and Space Administration and the Jet Propulsion Laboratory of the California Institute of Technology.

LURE measures the distance between the earth and the moon with unprecedented accuracy by firing short pulses of laser light at special mirrors on the moon and measuring the time it takes for the pulses to return to earth.

"Operation of the experiment is quite simple in concept," Faller explained. "Light is known to travel at constant speed in the vacuum of outer space. If we measure the length of time needed for a short pulse of light to travel to the moon and return, we know the distance it has traveled in terms of the speed of light. By shortening the laser pulse by a factor of 10, we should be able to time its return better and reduce the error to about 1 inch."

turn page

MOON *continued*

Since the earth-moon distance is not constant, and one of the major goals of the work is to acquire data on the motions of the dynamic earth-moon system, the experiment isn't a one-shot affair. Data taken over a long period is needed for comparison wih mathemetical models (equations) of the system; the models can then be used to generate more accurate ephemeris (position and distance prediction) tables essential to a variety of types of research.

In order to get a measurable and localized reflection from the moon, LURE uses special kinds of reflectors placed by the astronauts of Apollo 11, 14, and 15 at different places on the moon's face. These reflectors are not flat like the mirrors in your bathroom, but are rather like the shape you would have if you cut off a corner of a solid glass cube. One hundred to three hundred of these "corner reflectors," mounted in frames at these three Apollo sites, serve to return a laser beam precisely on its own path. Their action is much like the bicycle reflector that returns light from a headlight to the driver.

The laser beam is generated by a high-powered ruby laser and is directed at the reflector array by a large telescope. About 1¼ seconds after the pulse of light is sent out, it arrives at the moon, having spread to a diameter of about 2 miles. It is then reflected toward the sending telescope by one of the reflector arrays. By the time it returns to earth it has spread to a diameter of about 10 miles. Since the reflector and telescope intercept only a small portion of the beam in each case, the received light is only a tiny fraction of the original pulse (one part in a billion billion to be precise). A clock, capable of measuring the elapsed time to a billionth of a second, starts to run at the instant the pulse leaves and is stopped electronically by the pulse's return. The pulse are sent once every 3 seconds of a 10-minute period, in order to get enough data to be statistically significant. By averaging many shots, we obtain more accurate results than we would get by measuring only one or two.

Laser retro-reflectors similar to this were placed on the moon by Apollos 11, 14, and 15. Each dark circle contains one corner reflector.

Faller observed that we are lucky the moon isn't much farther away, because if it were, the reflected pulse would be so weak there would be no detectable reflection on most shots. For example, were the moon three times farther away, the returned pulse would be about 100 times weaker. Instead of receiving an average of about 10 photons (small bits of light) each time, there would be none most of the time. (A photon is the smallest sub-division of light that can exist. While two or six photons are required in a pulse to be seen by the unaided and completely dark-adapted eye, ordinary reading requires many millions of photons per second). The sensitive photocathodes that convert the returning photons to electrons—so that they can be detected electronically—require about 10 photons to release one electron. And it is this electron which is then amplified and used to stop the clock, indicating the end of a laser pulse's round-trip travel time.

Faller says that until more powerful lasers with sufficiently short pulses are available, we are indeed fortunate that the moon is as close as it is. □

NBS EXPERTS DEVELOPING ULTRASOUND STANDARDS

BECAUSE high-frequency sound (ultrasound) can damage body tissues, greater care must be taken in its uses, especially in medicine.

To combat this radiation hazard, Paul A. Hudson, Tom L. Zapf, and Robert F. Hetzker of the Bureau's Electromagnetics Division, Boulder, are developing measurement standards and methods for ultrasonic instruments. This program is vital to the enforcement of the Radiation Control for Health and Safety Act of 1968.

NBS scientists and engineers are applying their radio-frequency standards and know-how to ultrasound standards. They will use precision techniques and instrumentation to measure power, intensity, and radiation field patterns of ultrasonic tranducers.

"Ultrasound" denotes sonic frequencies beyond human hearing to about 40 MHz. Needed measurement accuracy and repeatability among manufacturing and research facilities cannot be achieved without establishment of standards for the quantities to be measured. As the program to develop such standards progresses, NBS will maintain close liaison with interested governmental agencies, universities, and manufacturers.

Medical applications of ultrasound provide the most compelling reasons for developing precision measurement methods in the ultrasound field. Here the consequences of uncertainty can be immediate and personal. The effects of ultrasound on tissue range from none through slight to destructive. Unfortunately the transitions between these consequences of ultrasonic treatment require much better understanding.

RF Standards

The NBS team is basing interim ultrasonic standards on electrical measurements obtained from the Bureau's radio-frequency (rf) standards. This system will calibrate commercial equipment with about 5 percent uncertainty.

The rf standards consist of measurement techniques and instrumentation that together furnish accurate values for rf current, voltage, power, impedance, and phase angle. Voltage, current, and phase-angle measurements will determine the electrical power delivered to or generated by ultrasonic quartz transducers. This, combined with the transducer efficiency, determines the power delivered to or received from the ultrasonic field.

Final ultrasound standards will employ systems for (a) more direct power measurement and (b) measuring and mapping ultrasonic field intensity.

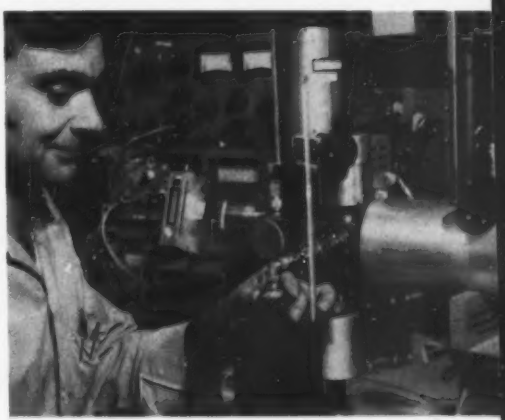
Additional NBS expertise applicable to the ultrasound program includes a theoretical method to calculate the far-field from near-field intensity measurements. Developed by David M. Kerns for electromagnetic fields, this procedure is adaptable to ultrasonic fields and will be implemented by using small probes for near-field scanning of ultrasonic transducers.

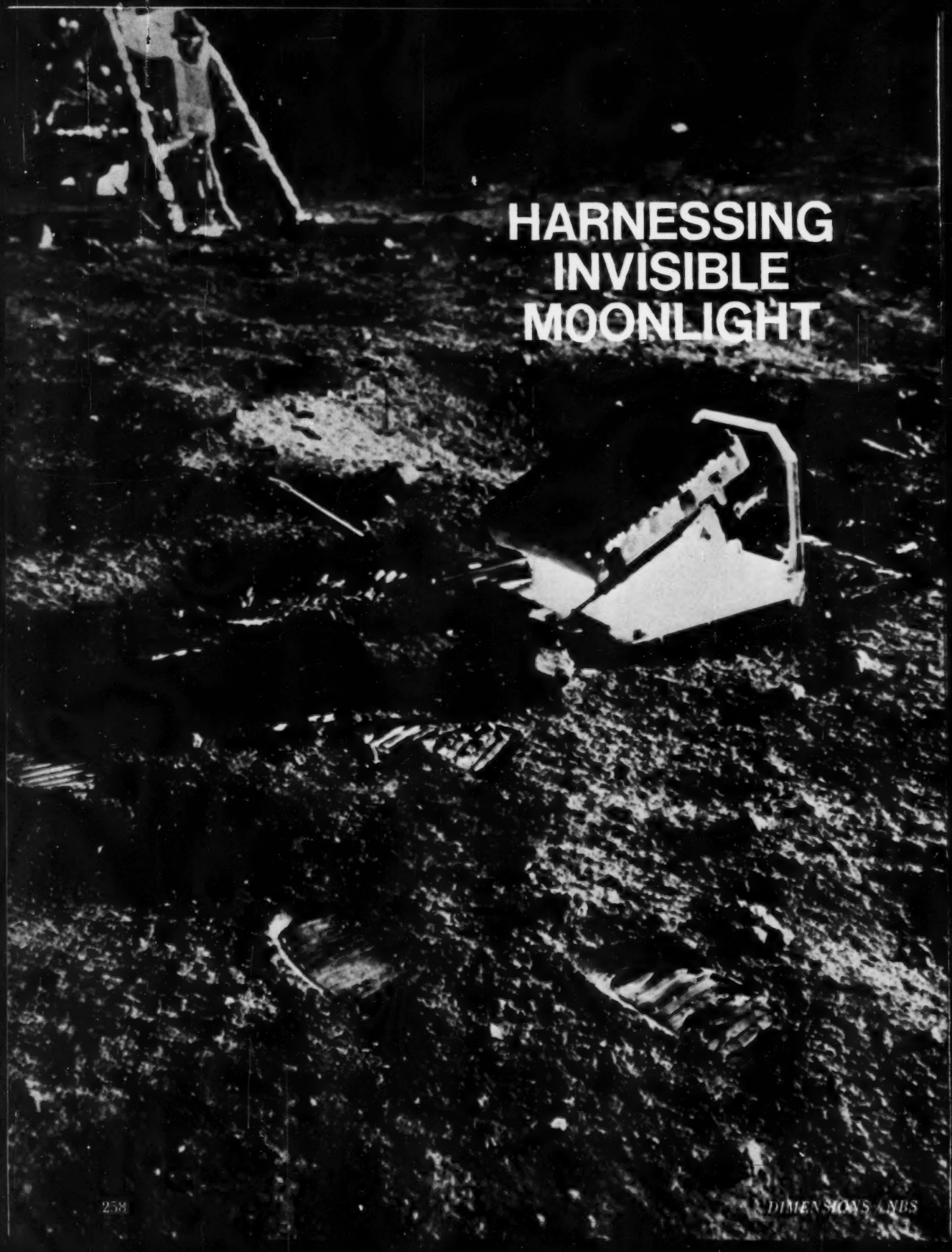
Field Intensity Important

In medical ultrasonics, field intensity is often of more interest than total power. Intensity is a measure of ultrasonic energy density and therefore is a quantity that, due to diffraction and interference effects, can vary from point to point throughout the ultrasonic field. Regions of constructive interference can have dangerously high intensity while others are well below tissue-damage thresholds. Consequently a knowledge of intensity distribution, or field pattern, is essential.

Under consideration are two methods of intensity mapping—probes and optical diffraction. Tiny piezoelectric probes can perform detailed mapping by measuring the ultrasonic energy that passes through a small hole (about 0.1-mm dia.) in the probe tip. This technique is most useful in the complex field near the transducer. More distant fields approximate plane waves whose regularity allows them to act, in the megahertz range, as an optical diffraction grating. Laser light incident normally on an ultrasound beam exhibits several orders of diffraction images. The optical intensity distribution over these images is a function of the ultrasonic intensity, and thus the laser beam itself acts as an intensity-measuring probe. □

R. F. Metzker partly submerges an ultrasonic transducer in the water column. The metal cylinders, fixed to an NBS twin-T bridge, are standard rf inductors and capacitors used here to measure transducer characteristics.




HARNESSING
INVISIBLE
MOONLIGHT

"the moon is the best understood 'standard lamp' in the sky."

GENERALLY we associate the moon with tides, eclipses, night illumination, and the space program.

To astrophysicist Dr. Jeffrey L. Linsky, the moon is the best understood "standard lamp" in the sky. Linsky is a fellow of the Joint Institute for Laboratory Astrophysics of the University of Colorado at Boulder and NBS. By analyzing lunar soil data gathered by Apollo 11, 12, and 15 astronauts and by National Aeronautics and Space Administration scientists, Linsky determines the average lunar infrared and microwave radiation occurring between successive new moons.[1]

The invisible radiation may then be used as the basic standard for measuring infrared and microwave radiation from astronomical objects with several times the accuracy and about 10 times the precision of other methods.

Because the size of the moon is large compared to the resolution of a radio telescope or infrared detector, it is suitable for studying extended area sources like the sun, distant portions of our galaxy, and even external galaxies which emit infrared and microwave radiation. It also works well for studying point sources like the planets and the stars by comparing the output of a carefully chosen point source to the lunar standard.

Astronauts' footprints on the barren lunar surface indicate a fine loose soil. Infrared and microwave radiation from the soil is instrumental in evaluating similar radiation from the sun, planets and sources in deep space. The resulting improvement in specta data of these sources should lead to a clearer understanding of their composition and atmospheric processes.

The Sun, The Planets, and Beyond

Using the lunar standard to recalibrate solar observations,[2] Linsky has achieved higher accuracy and resolution than was previously possible. Greatly improved infrared and microwave (including millimeter wave) data on the spectra of distant sources may produce much information about their composition and atmospheric processes. Millimeter wave studies of the solar chromosphere, the reddish part of the sun's atmosphere, should lead to a clearer understanding of the sun's inner workings such as the shockwave processes heating the solar atmosphere. A new field of solar millimeter wave spectroscopy may open up. Learning more about our sun should also increase our understanding of other suns or stars.

Astrophysicists make millimeter wave planetary observations. Improving these data lead to revisions in their concepts of the surface material of Mars and Mecury and the atmospheres of Venus, Jupiter, Saturn, and our own Earth.

Determining the Moon's Radiation

Infrared and microwave radiation from the moon is actually a reradiation of the sun's energy which strikes the moon. The amount of absorption and reradiation varies throughout the lunar day (about 1 month of earth time). It is the average radiation over a lunar day from the central portion of the lunar disk that Linsky uses as a standard.

The amount of reradiation at a given wavelength is expressed as "brightness temperature," and for the moon it depends on the properties of the lunar soil—on the surface and beneath the surface—and the surface and subsurface temperatures of the soil. Lunar soil tests conducted by Apollo astronauts and NASA scientists contributed data which helps substantially in developing models describing lunar radiation.

Lunar studies indicate the surface of the moon consists of a highly fragmented and slightly compacted dust at least several meters deep with widely scattered rock fragments on top. Radiation from the dust predominates because there is so much of it. However, during the lunar night, rocks remain considerably warmer than lunar dust and radiate at a higher brightness temperature.

Averaging over the lunar day and the area of the central disk smooths anomalies in the brightness temperature resulting from variations in solar heating and lunar soil properties.

Mean brightness temperatures of the moon vary depending on the wavelength, with microwaves being higher than infrared. The latter waves originate from the shallow depths of the lunar surface. The longer microwaves come from deeper, hotter layers.

Better Standards

Although 4 percent accurate from 10 micrometer to 1 meter wavelengths, the lunar radiation standard is limited by the uncertainty in the thermal and electromagnetic properties of the lunar soil. Linsky anticipates better values for these properties to improve the accuracy of the lunar standard. □

[1] Linsky, J. L., The moon as a proposed radiometric standard for microwave and infrared observations of extended sources, Astrophys. J. Suppl. Series, **25**, No. 216, 163-204 (Feb. 1973).

[2] Linsky, J. L., A recalibration of the quiet sun millimeter spectrum based on the moon as an absolute radiometric standard, Solar Phys., **28**, No. 2, 409-418 (Feb. 1973).

THE ENERGY COMPLEX— TARGET FOR TODAY'S TECHNOLOGY

by Dr. Richard W. Roberts, NBS Director

Excerpted from a speech given at the 3rd Urban Technology Conference, Boston, Massachusetts.

YOU'VE all heard the Biblical story of the prodigal son. As far as energy's concerned, we've been a prodigal nation. Our energy resourses have been used and abused throughout century. And we face a real dilemma in the years ahead for, as our domestic energy supply dwindles, our domestic demand increases.

The per capita consumption of energy in this country is six times the world averaged and growing at a rapid rate. In 1950, U.S. gasoline consumption averaged 305 gallons per person; in 1970, it was 460. Our use of natural gas has quadrupled in the last 20 years, petroleum use has doubled, electricity consumption has more than doubled since 1960 and is expected to double again by 1980. The only drop is in the use of hard coal, production of which is half what it was 10 years ago.

Our major sources of energy—petroleum, gas, and oil—are nonrenewable. Once used, they're gone forever. Domestic supplies are limited and, in some areas, are already insufficient to meet present demand. Major amounts of petroleum come from foreign sources—some 12 billion barrels in 1970—and the rate is growing. Such vast imports raise serious questions about balance of trade and dependency on other nations for a strategic material.

If we are to continue our present patterns of energy use, then clearly two things must be done: (1) we must use present resources as efficiently as possible while (2) we develop new sources.

There are areas, of course, that will require large-scale research and development programs. In his recent energy messages to Congress, President Nixon has called for increased support for such programs as breeder reactors, coal gasification, and controlled fusion devices.

In many areas of energy research, NBS is playing an active role. First, let's look at materials problems. I mentioned before that coal production has dropped dramatically in this country. This drop is not because we're running out of coal, but because most coals release soot and sulfur dioxide when burned. One possible solution is coal gasification, which involves the heating of coal and water under pressure to release $CO + H_2$, which can be converted to methane that burns quite cleanly. Another approach is magnetohydrodynamics, in which powdered coal can be burned and the resulting conductive gases passed through a magnetic field, producing electric current. It is important to know the viscosity of coal slag when designing an MHD generator, and NBS is making such measurements. We are also measuring the properties of various materials that may be used in the MHD generators.

As our fossil fuels are consumed we will be forced to develop new sources. Here, too, NBS is making a contribution. Nuclear reactors will come into widespread use. Especially promising are breeder reactors, which produce more new fissionable material than the primary fuel they expend. NBS is developing the basic neutron measurement techniques needed for characterizing such reactors and is providing data on the safety shielding that such reactors will require.

Solar energy offers great potential as a supplemental energy source. We are currently erecting and instrumenting a full 2-story home on our Gaithersburg site for use in solar energy studies. After accumulating data on its thermal performance, solar heating elements will be installed and their effectiveness evaluated.

Perhaps the ultimate future source is controlled nuclear fusion. This approach, which essentially duplicates the energy-releasing processes of the sun, will produce practically unlimited amounts of energy from small amounts of hydrogen. But formidable problems stand between us and the goal of controlled fusion. Temperatures of millions of degrees are required to initiate the fusion process, and a way must be devised to contain the reaction zone. NBS is providing the basic spectroscopic techniques needed to characterize the plasmas in which fusion is being sought, thus

providing important clues to the fusion process.

These new sources won't be ready tomorrow or even the day after. Their development will be a matter of years, even decades. But during this period, we can take positive steps to conserve our present sources. NBS' major conservation efforts are concentrated in building technology, an area offering vast potential for improvement. Building heating and cooling consumes about one-third of our total energy expenditures and as much as 40 percent of this expenditure is wasted. Nationwide, this energy loss corresponds to 65 billion gallons of oil every year.

The architect is faced with quite a complex problem when trying to optimize the thermal performance of his designs. In response, NBS has developed a sophisticated computer program for predicting a structure's heating and cooling loads around the clock. To validate the program, a full-scale home was erected in our massive environmental test chamber, fully instrumented, and subjected to a variety of thermal tests. Actual and computed values agreed quite closely. Through use of the program the designer can calculate the effects of various proposals and arrive at realistic figures for the size of heating and cooling equipment.

The NBS computer program, shown to be an important design adjunct, has been thoroughly demonstrated to the architectural and engineering community at workshops and is available for everyone to use.[1]

Let me digress a moment. It is one thing to design a building to minimize energy requirements. It is quite another thing to get such a building built. Why? Because the *initial cost* of the thermally efficient building will be higher than one of more conventional design. And, especially when public funds are involved, low initial cost is the name of the game. But it's really false economy. Insulation always more than pays for itself in saved energy; so do storm windows.

Let me give you an example. The architects for the Toledo Edison Building selected a chromium-coated, dual-wall insulating glass that costs $122,000 more than ordinary plate glass. The energy saved by the glass, however, will amount to about $40,000 a year, so in 4 years they'll be ahead of the game.

A popular phrase of a few years ago said that "We have met the enemy, and they are us." In a sense, that characterizes the energy shortage, for we all are massive energy consumers. But in the very massiveness of our energy use there is hope, for we all can cut back enough to make a real difference, yet still live the good life. It will take a national effort, the combined energy savings of millions of citizens, to avoid real shortages while we develop new supplies. Savings at home, at work, commuting, relaxing. Your savings—and mine. Starting now. □

[1] Use of Computers for Environmental Engineering Related to Buildings, Build. Sci. Ser. 39, available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 by SD Catalog No. C13.29/2:39 for $7.75.

The energy wasted heating and cooling buildings equals 65 billion gallons of oil each year.

HIGHLIGHTS

NBS/PBS/HEW TEST TV CAPTIONS

NBS will participate in a 1-year trial of television captions for the deaf—a feature of the NBS TV Time System—on the Public Broadcasting System (PBS). Sponsored by the Department of Health, Education, and Welfare (HEW), the project will enable many hearing-impaired people to evaluate the system under operational conditions. NBS has supplied TV sets modified to decode and display the captions and caption-generating and encoding equipment.

NBS-ELECTRIC POWER RESEARCH PROJECT SET

The Bureau's Electricity Division is developing a prototype system for on-site calibration of coupling capacitor voltage transformers. This is part of a joint research program between NBS and the Electric Power Research Institute aimed at increasing the accuracy of energy flow metering at interties. The significance of this program is obvious, considering that an uncorrected error of 0.5 percent in the metering of energy flow at an intertie in an extra-high voltage or ultra-high voltage substation can represent an inequity of more than $400,000 annually.

DATA ELEMENTS IN INFORMATION PROCESSING

Problems faced by the data manager in the design and maintenance of automated systems will be explored at a symposium to be held January 24-25, 1974, at the Bureau's Gaithersburg, Md., site. Cosponsored by NBS and the American National Standards Institute, the symposium will cover such topics as: The relationships of data management to programming and description languages, the organizational placement of data element management, the economics of data as compared to program and equipment investments, and the impact of changing the form of data presentations in integrated data bases.

Details can be obtained from Hazel McEwen, B265 Technology Building, NBS, Washington, D.C. 20234, telephone: 301/921-3551.

MEASUREMENTS ASSURANCE IN NUCLEAR MEDICINE

At the request of the College of American Pathologists, the Bureau is carrying out a series of radioactivity measurements tests to help determine the relative usefulness of different measurement techniques and the reliability of various instruments used in clinical laboratories.

Radioactivity solution samples have been distributed to participating laboratories for identification of the principal radionuclide and any radioactive impurities as well as for the assay of the sample for activity. The radionuclides used are among those incorporated into radiopharmaceuticals for physiological function studies, diagnostic scanning, and therapy.

SPEEDING UP TAXPAYER RETURNS

The Bureau's Institute for Computer Sciences and Technology has developed and delivered to the Internal Revenue Service (IRS) a unique prototype automation system to improve efficiency in the processing of taxpayer remittances. Ten of the prototypes plus a controller to connect them to a computer have successfully undergone system acceptance testing at the IRS Philadelphia Service Center. The NBS-developed equipment enables the IRS to more quickly deposit taxpayers' remittances by combining into one automated sequence the previously separate manual processes of endorsing checks, entering a payment record into the computer, preparing a remittance document, affixing a record number on the taxpayer's form, and creating an audit trail.

BUREAU AIDS HOWARD UNIVERSITY

Members of the Activation Analysis Section have been working with faculty and staff members of Howard University, Washington, D.C., to solve problems in applying nuclear techniques to physiology and oncology (study of tumors). Techniques were evaluated for irradiating the iridium "seeds" to solve standardization problems encountered in the preparation of radioiridium implants for tumor radiotherapy. Assistance was also provided in standardization of the radiation detectors on the Howard campus. The Howard staff members were introduced to practical activation analysis techniques, including radiochemical separation and use of sophisticated radiation detection instruments.

FLOW MEASUREMENT CONFERENCE

Water supply and waste water flows, air flows, and gas and liquid metering will be discussed at a Bureau-sponsored conference on February 26-28, 1974, at its Gaithersburg, Md., site.

Representatives of industry, regulatory bodies, standards organizations,

and instrument manufacturers will consider needs for improved flow measurements in the areas of energy, occupational safety, environmental quality, and the transfer of goods.

Contact L. K. Irwin, B214 Physics Building, NBS, Washington, D.C. 20234, telephone: 301/921-2101.

COMPUTER USERS SYMPOSIUM

The NBS Federal Information Processing Standards Task Group 10 will host a symposium on Computer Performance Evaluation December 4-7, 1973, at the Bureau's Gaithersburg, Md., site. Experts from both government and industry have been invited to speak on topics relating to the evaluation of computer performance to provide management data for design and procurement of new systems and the improvement of operation of existing systems.

Details are available from Richard Ensign, FEDSIM, Washington, D.C. 20330, telephone 202/274-8461.

HEARING PROTECTOR STANDARD

The Law Enforcement Standards Laboratory (LESL) of IAT has developed a voluntary standard for hearing protectors used on firing ranges, setting forth performance requirements and test methods which will insure adequate protection from the excessive noise found on the firing range. Titled "Hearing Protectors for Use on Firing Ranges," the standard is available as Stock No. 2700-00182 from the U.S. Government Printing Office, Washington, D.C. 20402, for 40 cents.

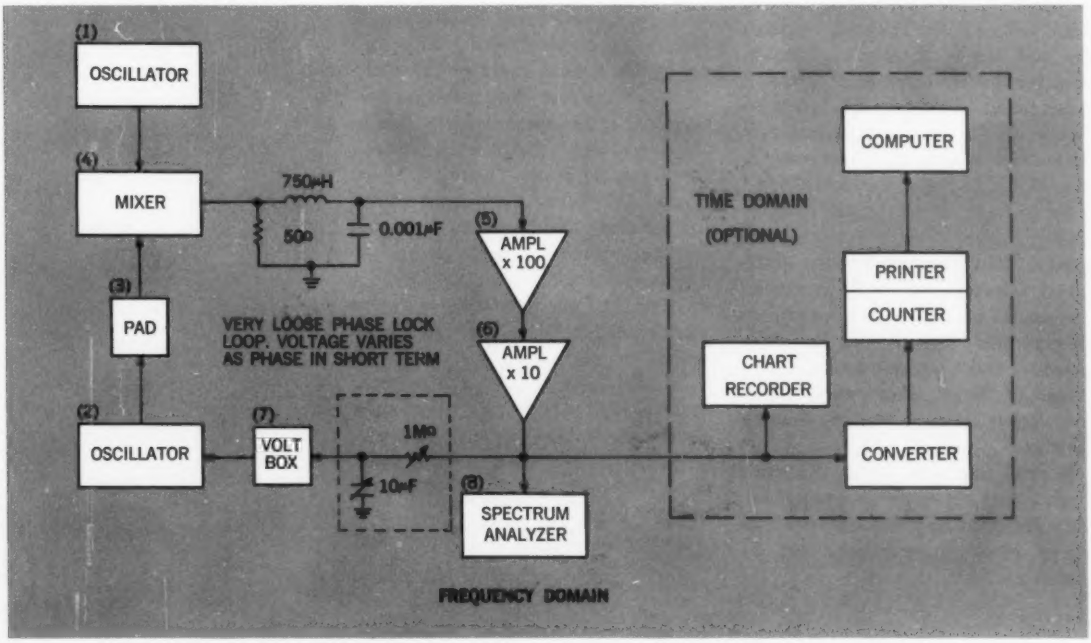
GUIDE TO FREQUENCY STABILITY MEASUREMENT

Organizing a frequency stability measurement can mean head scratching and even hair tearing. Sixty-five cents avoids such discomforts by buying a do-it-yourself manual that gives:

- concise definitions for specifying frequency stability in the time and frequency domains; a chart converts between formulas employed in the two domains;
- suggested techniques and apparatus for frequency stability measurements in the high-frequency (1 kHz-1 GHz) and X-band microwave (8.2-12.4 GHz) ranges;
- sample computations based on the defining formulas;
- more than 100 references.

Researchers J. H. Shoaf, D. Halford, and A. S. Risley of the Boulder laboratories compiled this information in the technical manual: Frequency Stability Specification and Measurement: High-Frequency and Microwave Signals (NBS Technical Note 632). It is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, by SD Catalog No. C13.46:632 for 65 cents. □

Frequency stability of oscillator (1) is measured, separately or simultaneously in both frequency and time domain.



AMERICA's not for Bur

A destructive fire breaks out somewhere in the United States every 12 seconds. In 1972, fire killed over 12,000 Americans, giving us a deaths-per-million-population rate twice that of second-ranking Canada. Fires also maimed and disfigured about 50,000 persons. Another 250,000 suffered lesser injuries; all had terrifying experiences. Conservative estimates put the economic loss at over 11.4 billion dollars, which gives us the doubtful honor of outstripping the rest of the world on a per-capita basis.

IN 1914 Congress made its first appropriation for a special fire-safety investigation by NBS—a study of fire-resistant properties of building materials. Today the Bureau's involvement ranges from research on toxic gas and smoke to improved equipment for the fire services. "Increasing involvement of NBS in fire-safety research reflects the widespread conviction that destructive fire can be effectively controlled by technology," notes Dr. Karl Willenbrock, Director of the NBS Institute for Applied Technology. "Given a reasonably determined research effort," he continues, "we should soon be able to provide a fire-protected environment in which materials resist ignition and are slow to spread flame, where detection is fast, alarms reliable, and suppression effective."

A brief overview of the Bureau's current fire research programs follows. Included are research projects run by outside organizations that are funded by NBS.

Contributions to Fire Prevention

Nearly all of the NBS fire-safety projects deal with fire prevention. Professor Francis Brannigan of Montgomery College, consultant to NBS on multiple-dwelling fires, has conducted a field study of the structural and building design factors contributing to the spread of fire in non-fire-resistive, multiple-occupancy dwellings, typically "Garden Apartments." He found that most of the deficiencies could have been corrected by preserving the integrity of the fire resistive sheath that serves as a fire barrier. Better informed and more alert inspectors could have eliminated defects of this sort.

Several other NBS projects are concerned with obtaining information on the fire resistance and burn patterns of building materials and structures. These data will be used to promulgate better fire codes.

A recent NBS study showed that

turn page

rning

Where there's fire there's smoke, and the smoke is often more lethal than the fire. Study of smoke and gas formation in fires is an important part of the NBS Fire Safety Research Program.

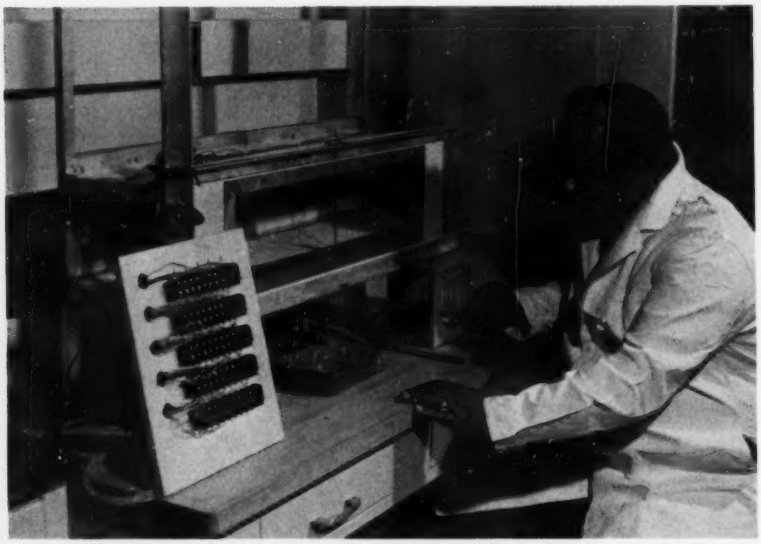
The death rate from fire among children under 5 is three times that of the rest of the population. (Photo courtesy of Buffalo Courier-Express.)

America *continued*

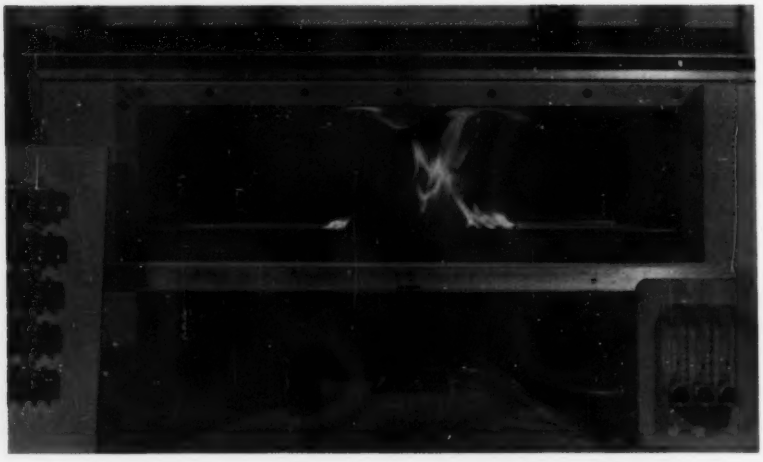
28 percent of accidental garment fires resulted from match or lighter ignition; victims are usually children. To attack this hazard NBS has contracted with a private research group to work out modifications of book matches and cigarette lighters to make them more "child-proof."[1]

Firefighter Training and Education

According to F. James Kauffman of the National Fire Protection Association, firefighters need more and better education. Under an NBS contract, NFPA compiled training packages to teach firefighters how to recognize important evidence and to assist fire officers in drawing accurate conclusions about the fire cause, its point of origin, and whether or not it was accidental. These packages are now being field tested for effectiveness.



Small-scale laboratory experiment simulates flame spread over flooring material in a building corridor. Garnett Robinson of the NBS Combustion Research Section initiates ignition at center of specimen and monitors flame propagation.



Two projects on operations research attack the problem of firefighter effectiveness at the administrative level. Donald R. Colner of the Technical Analysis Division is investigating ways to determine the most efficient location of fire stations and their manning levels within budget limits. Patsy Saunders and coworkers in the Applied Mathematics Division have developed a computerized procedure for sequencing the purchase and retirement of fire engines. The model has been applied to data from the Washington, D.C., Fire Department. Details were given in the November 1972 *NBS Technical News Bulletin*, p. 263.

Since increased concern and awareness of fire hazards may reduce accidental fires, Laura B. Buchbinder (NBS Research Associate; The Cotton Foundation) is working to determine precisely what people most need to know to avoid and control garment fires (see page 270). Using available records, she has sought to identify the activities just preceding an apparel fire and then to classify and relate them to the age and sex of the victims.

FFACTS or Flammable Fabrics Accident Case and Testing Systems, a unique computerized inventory of fabric fire accidents, is based on over 2,000 case histories that are continually supplemented as newer fires are studied. FFACTS collects these case histories, quantifies them, tests fabric remnants to verify reports, and uses the resulting data to identify fabric flammability hazards. It is an important part of the Bureau's expanding National Fire Data System. (See *NBS Tech. News Bull.*, May 1973, p. 114.)

Reducing Fire Hazards

The problems of reducing or eliminating fire hazards fall roughly into two categories: (1) those dealing with the formulating, applying, and testing (determining how effectively they reduce the hazard) of fabric flammability standards and (2) research on ways to increase fire

resistance of fabrics and building materials.

Benjamin Buchbinder and Allan Vickers of the Fire Technology Division use statistical methods to compare the effectiveness of flammable fabric standards with modification of ignition sources such as matches, cigarettes or kitchen ranges in hazard reduction. The Fire Technology Division provided the Commerce Department with the technical know-how needed to develop a recent landmark in fire-safety: the flammability standard for children's sleepwear.

The work of Michael D. Mayer on the use of simulated apparel fire accidents to determine relative flammabilities is described on page 268.

Several studies are underway on the spread of fire over home furnishings. They include measuring the spread of fire over textiles; evaluation of flame spread test methods for carpets and other flooring materials; and determining a model to predict flame velocity for radiant test panels.

Dan Gross and Jin B. Fang of the Center for Building Technology have developed a procedure to evaluate the contribution to fire growth of panels and assemblies in a room corner with a standardized wood crib representing the incidental fire (which might actually be in a wastebasket). These data are needed to establish rational tests and design criteria for reduction of fire hazards in buildings.

Closer to fundamental science are two projects on the chemical mechanisms responsible for the action of flame inhibitors. John W. Hastie of the Inorganic Materials Division is investigating the role played at the molecular level by inorganic chemical additives in fire retardency and flame inhibition. Professor Robert Barker (Clemson University) is determining for NBS the effect of flame-retardant chemicals on textile subtrates and how they work.

Fire Protection of Buildings

Researchers in the NBS Fire Program are working closely with other agencies and members of industry to upgrade fire detection in buildings. They have recommended criteria for fire detection required by the Housing and Urban Development (HUD) for Operation Breakthrough. Members of the NBS program have also acted as advisors to HUD in writing new proposed minimum property standards that will require detectors and sprinklers in highrises. In cooperation with building officials, they have suggested new building code requirements for fire detectors in residences.

Claude C. Gravatt of the Polymers Division developed a device for optical detection of aerosols, a light-scattering instrument that sizes particles one at a time, essentially in real time, at rates up to 50,000 particles per second. Another of his devices is an experimental smoke detector for monitoring changes in carbon content rather than total particle density.

Smoke Studies

Treatment of burn and smoke victims is hindered by a lack of fundamental understanding of the behavior of fire and its combustion products. At least two Bureau projects are aimed at increasing this knowledge.

One of these, headed by Tom King (NBS Research Associate; Armstrong Cork Co.), is concerned with simultaneous smoke and carbon monoxide measurements from plastic and cellulosic materials. An effort is being made to correlate smoke optical density with the mass concentration of smoke.

Merritt Birky (on leave from NBS to U. of Utah) is participating in a multidisciplinary study of the thermal degradation of cellulose (including Douglas Fir), a polyvinylchloride, and a flexible polyurethane. Supported by the National Science Foundation, the technical group at Utah is developing a method to generate and characterize the products of combustion, and the physiological and toxic effects of these products on rats is being observed. □

New Director of NBS Fire Programs

Dr. John W. Lyons, former manager of Commercial Development for Monsanto Industrial Chemicals Company and head of the firm's Fire Safety Center, has been named Director of Fire Programs at the Bureau.

His appointment was announced by Richard W. Roberts, Director of NBS. Roberts said Lyons' appointment marks the continued strengthening of the Bureau's efforts to reduce the Nation's fire toll by creating an environment protected from fire through applied technology.

"Dr. Lyons has a distinguished record as a nationally respected researcher, author and fire control business manager," Roberts said. "He will make an enormous contribution to research on the understanding of the causes of fires, to fire standards and to the consumer-oriented work of the Bureau."

Employed by Monsanto since 1955, Dr. Lyons' experience includes bench research in phosphorous chemistry (especially applications of phosphorous compounds), in rheological phenomena, and in surface and colloid chemistry. He has administered synthesis and applied studies of phosphorous compounds as ion sequestrants, deflocculants, and fire retardants.

[1] See NBS Tech. News Bul. **56**, No. 9 (Sept. 1972) p. 215 and Tech. News Bull. **57**, No. 6 (June 1973) p. 134.

NBS PROMOTING USE AND DEVELOPMENT OF FIRE-SAFE CLOTHING

IN human terms, nothing is more tragic than the death or crippling of a child by fire. To help guard against such tragedy, NBS provided the technical base for the Commerce Department's 1971 fabric flammability standard for children's sleepwear. The mandatory standard proscribes rigid testing techniques and fire-safe requirements for sleepwear sizes 0-6X. Such regulations protect individuals from the dangers involved in wearing highly flammable clothing.

Two recent incidents demonstrate the effectiveness of the children's sleepwear standard. These two cases exhibit the same pattern of events as many fire accident histories compiled by the Bureau. The difference is that the children who were wearing clothing that complied with the standard went relatively unharmed.

The first incident took place during a family camping trip. The parents put their children to sleep in a tent lighted by a gas lantern. Later they saw the tent in flames, rescued the two children and rushed them to a nearby hospital. The doctor said the children were spared serious, possibly fatal burns (only their hands and feet were injured) because the pajamas they were wearing had protected their bodies.

The second near-tragedy occurred when a mother, to amuse her baby, placed a hair dryer on a table above crib level and directed the air flow toward a mobile over the baby's head. Within a short time the mother responded to cries and found the dryer lying across the baby's legs. While the heat had caused the pajamas to melt, they did not burn.

The children involved in the preceding cases were under 6 years old. NBS' analysis of the data on fire accidents involving fabrics indicates that children in the 6-12 age group are also subject to unreasonable danger. A regulation extending protection to that group is being considered. NBS will continue to provide the technical base for this and other standards.

All fabrics and garments presently under manufacture for use in children's sleepwear must meet the current standard. A few materials that were available before the standard went into effect are still on the market today. As an aid to the concerned consumer, many manufacturers provide fabric flammability information about their products by labeling the goods.

Methods of making and laundering garments can affect their ability to remain flame retardant. The consumer should guard against destroying flame retardancy.

TIPS TO THE CONSUMER

- Buy fabrics and garments labeled flame retardant
- Sew synthetic fabrics with syn-

thetic fiber thread (For instance, sew nylon or polyester fabrics with nylon or polyester thread)

- Follow manufacturers' laundering instructions rigorously, especially with regard to:
  - Chlorine bleaches
  - Hard water
  - Low- and high-phosphate detergents
  - Drying in sunlight

COOPERATIVE EFFORTS WITH INDUSTRY

The Bureau's work with flammable fabrics is beneficial to many parties and can generate cooperative efforts through such projects as the Research Associate Program at NBS.

M. Dainis Mayer of the Man-Made Fiber Products Association has recently completed a research effort for the Bureau on the relative flammability of fabrics. By simulating fire accidents involving apparel, he has determined the flammability characteristics of a number of man-made fibers. He tested many materials popular with the consumer: broadcloths, lightweight knits, tricots, slack-weight fabrics like twills, double knits and permanent press materials.

Mayer classified fabrics according to the ways in which they burn:

- Flames spread rapidly with increasing intensity (light-weight cellulose-containing fabrics, including cotton/polyester blend broadcloths),
- Flames spread slowly with increasing intensity (heavy-weight cellulose-containing fabrics, including cellulose/polyester blends such as denims and heavy permanent press slack material),
- Flames spread down and around the garment rather than up the garment (nylon tricot, for example), or
- Fabrics either do not ignite or they self-extinguish (cellulosic and synthetic flame-retardant fabrics and such materials as 100 percent polyester double knits).

Mayer discovered that most medium-weight fabrics, including much of the permanent press, tended to fall between the first and second classifications.

The simulated accidents were based on actual accident patterns found in case histories compiled by NBS. The most common causes of apparel fires are: cooking range accidents, matches, and small open fires and heaters.[1]

Using these findings, Mayer developed four common accident situations. He then put life-size, fully dressed mannequins into those situations and analyzed the results.

Mayer suggests that a test method which measures relative flammability of fabrics, garments and components be the basis of future flammability standards. Such flammability tests would show the relative burning characteristics of fabrics, while the tests used for the current children's sleepwear standard are essentially pass-fail: If the fabric does not self-extinguish, it does not qualify for use. Adults, with a capacity to "defend" themselves, do not need absolute fire protection from their clothing, he claims.

His research also indicated that the danger of severe injury from clothes burning at the seam (as could occur in synthetic-fabric garments sewn with cotton thread) is negligible in accidents involving adults. □

[1] Slater, J. A., Buchbinder, B., and Tovey, H., Matches and Lighters in Flammable Fabrics Incidents: The Magnitude of the Problem, Nat. Bur. Stand. (U.S.), Tech. Note 750. Available as SD Catalog No. C13.46:750 from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 55 cents.

FIRE:

HUMAN ACTION AND REACTION

IS human behavior to some extent responsible for all fire mishaps involving an individual? Ms. Laura Buchbinder from the Cotton Foundation, currently a research associate with the Bureau's Fire Technology Division, is testing that hypothesis on case histories researched by the NBS Flammable Fabrics Accidents Case and Testing System.[1] She has discovered a link between certain activity patterns related to age and sex and the incidence of fire accidents.

Ms. Buchbinder's research indicates that people are not fully aware of the possible consequences of many of their actions, and that this condition should be taken into consideration in developing programs of public education on the topic of fire prevention and control.

For example, such common activities as cleaning a paint brush can become hazardous if the action takes

A common and hazardous mistake: pouring a flammable liquid on lighted coals.

place in a small, enclosed area in the presence of an ignition source—the pilot light from a hot water heater in a utility room, for instance. In such a case, the person concerned is likely to be a man. Research indicates that the victims of accidents involving flammable liquids and gases, explosives, and high-voltage electricity are most often men.

Women, more apt to be engaged in cooking activities, are likely to suffer burns from accidents caused by a hot range. Often their actions bring the sleeve of a loose garment, such as a nightgown or robe, into contact with the ignition source. They also may receive more severe burns than men, a result of wearing loosely fitting clothes as opposed to the more contoured pants and shirts. Here, as in all apparel fires, both the flammability of the fabric and the style of the garment determine to a great extent whether contact with an ignition source will be made, whether that contact will cause a fire and, if so, how severe the injury will be.

Children's activities sometimes include, unfortunately, playing with matches and other ignition sources. This behavior accounts for most of the fire injuries incurred in the 0-10 age group. NBS has moved to reduce such injuries by developing a flammability standard for children's sleepwear which was issued by the Department of Commerce.

A person's immediate reaction to a fire mishap has great bearing on how severely the individual may be injured. People over 65 show the least ability to "defend" themselves once an accident occurs. (Children, although they may not "defend" themselves, are more apt to have help close at hand.) The elderly tend to be slower to react and less logical in their choices of defense. Consequently they suffer more severe injuries from similar accidents than does any other age group. □

[1] See FFACTS, Nat. Bur. Stand. (U.S.), Tech. News Bull. **57**, No. 5, May 1973, pp. 114-116 for a discussion of this program.

New Clinical Standard Reference Materials Available

NBS has issued three new clinical Standard Reference Materials (SRM's)—potassium chloride, sodium chloride, and cortisol—that will provide a means to improve the accuracy of several clinical determinations.

The accuracy of measurements in clinical laboratories is of vital importance to the diagnosis of disease and treatment of patients; and inaccurate analysis could lead to the improper treatment of a patient. Standards are also necessary to improve interlaboratory comparisons and help guarantee compatibility of test results obtained over an extended period of time.

POTASSIUM CHLORIDE AND SODIUM CHLORIDE

Based on both potassium and chloride analyses, SRM 918—Potassium Chloride—is certified to be 99.9 percent pure. Because no highly accurate methods exist for the determination of major quantities of sodium, SRM 919—Sodium Chloride—is provisionally certified as 99.9 percent pure solely on the basis of the chloride analysis.

Chemical assay, as well as analyses for specific impurities, indicate that SRM's 918 and 919 may be considered essentially pure, except for moisture due to occlusion. The purity value of 99.9 $\pm$ 0.0 percent is based on samples dried over magnesium perchlorate. The potassium content was determined by a combination of gravimetric and isotope dilution mass spectrographic analyses. A coulometric argentimetric procedure was used to determine the chloride content. Based on a series of independent measurements, the samples were considered homogeneous.

Potassium, sodium, and chloride play important roles in body functions. Potassium is the major intracellular cation, sodium the major extracellular cation. The chloride ion plays an essential role in the maintenance of normal acid-base balance and physiological homeostasis. Changes in the concentrations of these ions can be indicative of diabetic coma, toxemia of pregnancy, alimentary tract infections, renal and cardiac failure, cellular breakdown, and adrenal cortical insufficiency.

CORTISOL

Cortisol is one of the 17-hydroxycorticosteroids. The concentration of cortisol in plasma and urine is a sensitive index of the adrenocortical function. Low corticosteroid values are found with Addison's disease. Elevated values are noted with Cushing's syndrome, eclampsia, and acute pancreatitis. Cortisol, or its oxidized form cortisone, is administered in cases where adrenocortical hormone therapy is indicated. During such treatment, the levels of corticosteroid must be monitored closely due to the individual nature of the treatment and the possibility of undesirable physiological side effects.

SRM 921, Cortisol, is certified as 98.9 percent cortisol and 99.9 percent total steroids. The other steroids present are 21- dehydrocortisol, 21-*O*-acetyl-cortisol, 21-dehyxrocortisone, and cortisone. Identification and quantification of the four steriod impurities were accomplished by Fourier-transform proton-magnetic-resonance (pmr) spectroscopy and thin-layer chromatography (tlc). The cortisol assay has an estimated accuracy of 0.2 percent.

Each of the SRM's is available from the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C. 20234. Both SRM 918 and SRM 919 are available in 30-gram units at a cost of $44 per unit. SRM 921 is priced at $63 for a 1.0-gram sample. □

NBS REPORTS
SENSOR PROGRESS

AN array of piezoelectric sensors on the chest or forehead of an anthropomorphic dummy used in crash studies can provide the pattern of forces experienced by the dummy and also give the entire time history of the crash at each point.

Piezoelectric sensors matching the mechanical impedance of flesh can be applied like adhesive tape for acoustic holography in biomedical studies or can provide a convenient way to monitor a person's pulse.

An array of piezoelectric sensors can be used to determine the pattern of vibration of thin metal structures in cases where holography would be expensive or inconvenient.

Piezoelectricity (charges of electricity produced by pressure) in naturally occurring biological and polarized synthetic polymers is becoming increasingly recognized as an important phenomenon[1] and one capable of many applications.

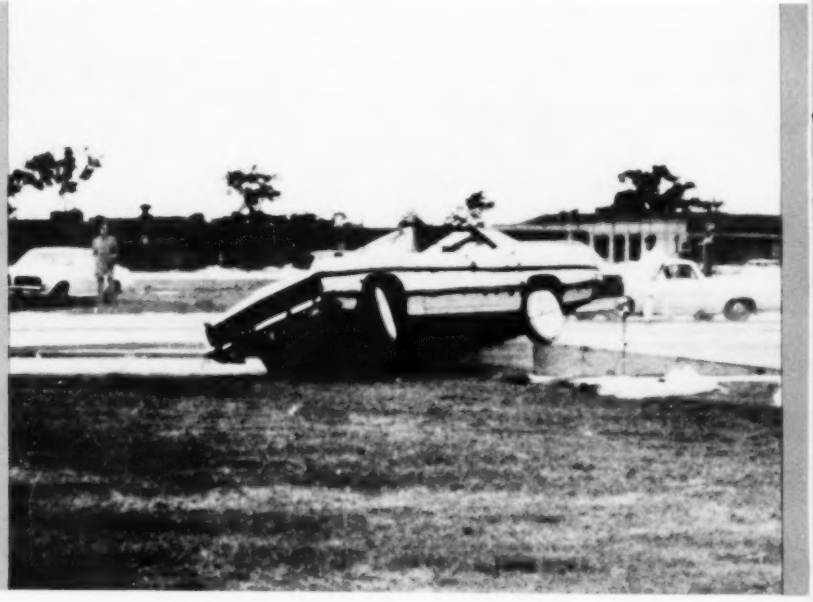
Physicists at NBS report progress in inducing and improving piezoelectric activity in polymers. Seymour Edelman and his colleagues in the Bureau's Electronic Technology Division, using material selection and poling techniques, have developed polymers with significant piezoelectric activity which can now be used to make instruments for measuring dynamic stress, pressure, and vibration.* A piezoelectric sensor has been made which functions as a stress gage, or when vibrated, as an accelerometer.

Piezoelectricity and pyroelectricity (charges of electricity produced by changes of temperature) in typical synthetic polymers are reasonable consequences of straining an elastic material having preferentially ordered and immobile molecular dipoles imbedded in it. As sensing materials, piezoelectric polymers are much lighter and cheaper than ceramics and crystals and, not being brittle, are less likely to be damaged by shock or explosion. They can be produced in thinner sheets than can ceramics or crystals and are not affected by water, oil, or common chemical solvents.

A wide range of chemical and mechanical properties are available in suitable polymers and combinations of polymers and dopants. Sensors can be made in almost any size

* This work has been supported by Naval Ordnance Laboratory, Advance Research Project Administration, and National Aeronautics and Space Administration.

Sensors developed by NBS scientists could enhance data acquisition by engineers working to improve automotive safety by means of crash dummy investigations of the kind illustrated here.



or shape and can be applied to almost any kind of solid or compliant surface. This freedom in choosing properties and design means that polymeric sensors can be engineered for unique applications.

NBS Sensors Developed

NBS researchers have attached sensors to the exposed areas of ball bearings. They have used the insulation of coaxial cable as a sensor both underwater and in the ground. Similar sensors have been made of hollow tubes or pipes. The feasibility of vulcanizing sensors into the tread of airplane tires to permit landing studies is now being considered.

The NBS reseachers' piezoelectric sensors consist of a sandwich of two thin polymer sheets with evaporated metal electrodes on both faces. The sheets are cemented or fused together so that charges of the same polarity appear on the inner faces. The center conductor of a coaxial cable is connected to the electrodes on these faces and the shield of the cable is connected to the electrodes on the outer faces. In this way all exposed surfaces are at ground potential and the signal potential inside the sensor is well shielded.

The Poling Technique

Poling is a technique for making a material electrically active. The basic poling technique is to heat the material until it softens; apply as high a dc field across the thickness as can be sustained without arcing through the specimen; then, cool the material to room temperature with the field applied. Mechanical deformation (by stretching, rolling, pressing, and vibrating) carried out before or during the poling process improves the result.

It is assumed that the structure of the polymer contains electric dipoles, and that the process of poling causes a number of the dipoles to become aligned and oriented in the direction of the field. Immediately after poling, the activity falls off rapidly. After an initial period, the residual activity remains fairly constant for about a year in well-poled specimens. After this, activity falls off, as though the accumulated effect of the accidental losses destroyed the organization of the dipoles and no longer held them in alignment.

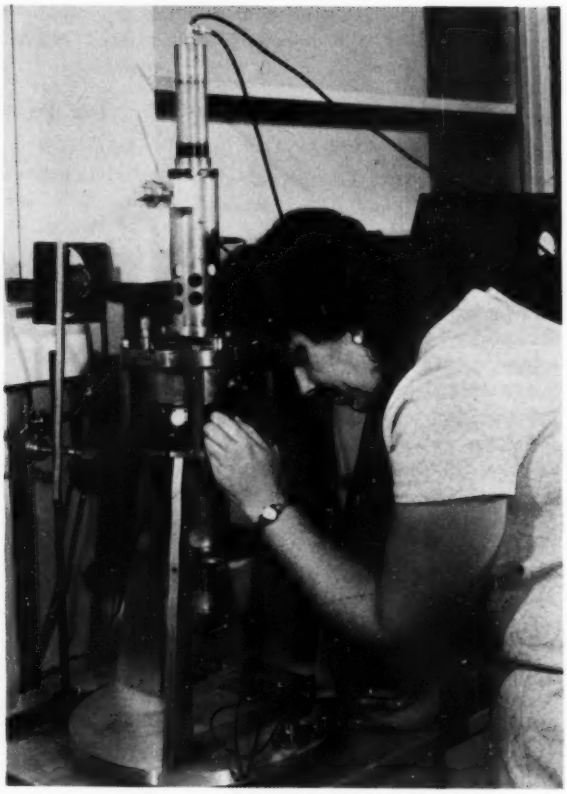
This hypothesis would indicate that any factors changing the thickness of the specimen will cause charges to appear on the surfaces. Effects of two such factors (pressure and temperature), have been observed with good correlation between them.[2]

Data for the piezo- and pyroelectric properties show that polymers compare favorably with traditionally used transducer materials. The effect of temperature (the pyroelectric effect) is quite large in some of the polymeric materials; comparable with the best crystalline pyroelectric materials. A number of heat detectors and prototype intrusion detectors using this effect have been made. □

[1] Edelman, S., Piezoelectric Polymer Stress Gages, preprint of a paper presented at the Symposium on Advancements in Instrumentation for Civil Engineering Applications, Air Force Weapons Laboratory, Kirtland AFB, N. Mex., on May 9, 1973.

[2] Broadhurst, M. G., Malmberg, C. G., Mopsik, F. I., and Harris, W. P., Symposium Volume of the Electrochemical Society—Conference on Electrets, Charge Storage, and Transport in Dielectrics—Miami Beach, Fla., Oct. 8-13, 1972.

Calibration of Quartz Control Plates



Marilyn Dodge, Optical Physics Division, taking a reading on the polarimeter.

SUCROSE—the most inexpensive sweet sugar—is the most commonly used sweetening agent in home use.

The entire 10 million tons of cane and beet sugar (sucrose) used by the United States each year is bought, sold, and the tariff set and paid on the basis of a standard for rotation of polarized light calibrated by NBS.

Recently, Dr. Wm. Bruce Olson and Miss Marilyn Dodge, working with other Bureau scientists, developed an instrument to determine accurately the rotation of these standards. Using a photoelectric azimuthal polarimeter with electronic readout, they obtain high accuracy and avoid operator bias. Similar optical rotation analyses are increasingly used in quality control procedures for the pharmaceutical industry.

Development and Maintenance of Standards

By the middle of the 19th century it was well established that the amount of sucrose dissolved in water could be determined by the degree of rotation of a beam of plane polarized light passing through the solution. Instruments called saccharimeters or polarimeters were developed to measure this degree of rotation. Because an error of 0.02° of rotation could cost the sugar industry over $1 million a year, the accurate calibration of these instruments is of some concern.

Quartz rotates the plane of polarization of light almost the same as does sugar; hence, carefully manufactured quartz plates can serve as the equivalent of standard sugar solutions. These quartz plates are, of course, much more stable and easier to handle.

An interesting example of the necessity of constant calibration vigilance arose with respect to the quartz control plates used in calibrating these polarimeters. From time to time, usually when a change of personnel had occurred, some changes in the accepted value of the United States Standard Quartz Plate Number 1 were noted (although the accuracy of the plate still met all U.S. Customs requirements). Because the Bureau's polarimeter was, to some degree, outmoded and inaccurate, NBS staff members set out to develop a system that would be comparable in accuracy to the best in present instruments. The newly designed instrument meets this goal. □

NBS TO EXPLOIT IODINE STABILIZED LASERS

As part of a constant effort to develop precise wavelength standards and spectroscopic sources, scientists at NBS have completed a study of the performance of iodine stabilized lasers at 633 nm; (making absolute wavelength measurements of some of the laser "lines" most suitable as wavelength standards).

Drs. W. G. Schweitzer, Jr., Ernest G. Kessler, Jr., Richard D. Deslattes, Howard P. Layer, and J. R. Whetstone have studied several embodiments of these lasers, including operational details, stability, reproducibility, and absolute wavelength determinations.[1]

The improved signal-to-noise ratio in the locking system of the $^{129}I_2$ stabilized He-Ne iodine laser has resulted in a more compact and reliable package than has hitherto been available. Ten devices have been produced at NBS for use in laser calibration, X-ray interferometry, gravity measurements, earthquake and weapons studies, and analyses of highly stable material.

Stabilized He-Ne lasers operating near 633 nm are widely used in engineering and scientific metrology where they function as secondary wavelength standards. These lasers are in general subject to systematic frequency shifts due to pressure uncertainties in the plasma tube and to optical feedback. They must be calibrated frequently when accuracy near 1 part in 10^8 is required. Direct interferometric calibration against the ^{86}Kr standard is possible but is relatively tedious and expensive. On the other hand, a heterodyne comparison of such a laser against an iodine stabilized laser is both rapid and precise, with measurement errors at or below 1 part in 10^9 easily achieved. In applications such as the free-fall gravity measurement it is desirable to incorporate an iodine stabilized laser directly in the measurement apparatus. The very high frequency stability of the iodine stabilized laser is utilized in applications such as earthquake and weapons studies.

Technical Summary

The authors have given a description of lasers stabilized to components of the ^{129}I spectrum in the region of the 633 nm laser lines from ^3He-^{20}Ne and ^3He-^{22}Ne. They have shown how the operational characteristics such as power output, peak size and width, are related to each other and to some of the controllable parameters such as excitation level, iodine absorption, and iodine pressure. These lasers exhibit a frequency stability for 10 s sampling time of about $2 \times 10^{-12}v$ and a resetability of about $1 \times 10^{-10}v$.

The absolute vacuum wavelengths for several iodine lines have been measured against the ^{86}Kr standard. Among these are:

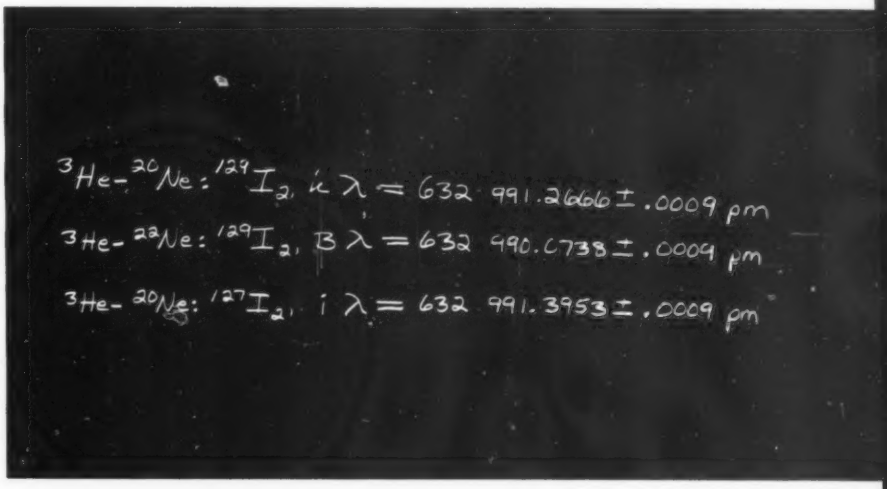
^3He-^{20}Ne:$^{129}I_2$, k λ=632 991.2666±.0009 pm

^3He-^{22}Ne:$^{129}I_2$, B λ=632 990.0738±.0009 pm

^3He-^{20}Ne:$^{127}I_2$, i λ=632 991.3953±.0009 pm

These results were obtained on the assumption that the defined value for the krypton standard was to be associated with the center of gravity of the line profile. □

[1] Schweitzer, W. G., Jr., Kessler, E. G., Deslattes, R. D., Layer, H. P., and Whetstone, J. R., Description, Performance and Wavelengths of Iodine Stabilized Lasers, Applied Optics, Optical Society of America, Washington, D.C., January 1974 (in press).



U. S. GOVERNMENT PRINTING OFFICE : 1973 O - 526-817

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